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THE INTERNATIONAL AERONAUTICAL CONGRESS AT BERLIN.

By A. LAWRENCE ROTCH, Director of the Blue Hill Meteorological Observatory, dated September 4, 1902.

An International Aeronautical Congress was held at Berlin May 20 to 24, 1902, on the occasion of the third meeting of the International Committee for Scientific Aeronautics, appointed by the Paris Meteorological Conference of 1896. Of this committee there were present the president, Prof. Dr. Hergesell, of Strasburg, Prof. Dr. Assmann and Mr. Berson, of Berlin, General Rykatchef and Colonel Kowanko, of St. Petersburg, Professor Cailletet and M. Teisserenc de Bort, of Paris, and the writer, who is the American member. There were also present at the Congress, by special invitation, about one hundred military and civil aeronauts and representatives of meteorological institutions, the writer representing the United States Weather Bureau by request of its chief.

The opening of the Congress in the great hall of the Reichs-

tag building was a brilliant event. Prince Frederick Henry, of Prussia, appeared for the Emperor of Germany. Both the Imperial and the Prussian governments were represented, and the chief European nations, except France, sent the commanders or officers of their military balloon corps. After the usual formal greetings, the representative of the Prussian Minister of Education spoke as follows:

The Royal Government is much impressed with the importance and necessity of an exchange of ideas between the savants of all nations in matters concerning meteorology and terrestrial magnetism, since international cooperation in these branches of science is the indispensable forerunner of progress. This was indeed recognized as early as 1780, by the founding on German soil of the "Societas meteorologica Palatina," which undertook the task of beginning systematic weather observations in Europe, with the hope of extending them to other parts of the world. On account of the existing state of affairs its efforts were of short duration and for a short time savants were allowed to labor independently, but with the foundation of magnetic investigations by Gauss and Weber the sagacious idea of organization acquired new life and pressed for realization, especially through the development of navigation, which has the greatest interest in the accurate observation of weather phenomena on the ocean. The antarctic discoveries of James Ross, and the successful efforts of American navigators to shorten ocean voyages, gave a new impulse, and so there arose the proposition of organizing a meteorological service at the first congress of the maritime nations held at Brussels in 1854, although it was not until 1873, during the Vienna Exposition, that the first meteorological congress convened there laid the foundation of an international weather service. The international committee, appointed at that time, met at first annually, but later at intervals of two or three years. With its increasing activity the necessity of dividing the work manifested itself, and thus special commissions were formed, of which one meets here to-day and whose third gathering will probably be as fruitful as its preceding meetings. In a field where there is only interest in research may the bonds uniting the representatives of cultured nations ever become closer!

In the name of the Prussian Meteorological Institute, its director, Dr. von Bezold, spoke as follows:

The ascensions of manned balloons and kites have proved latterly an important means of exploring the atmosphere. Consequently, meteorology should rejoice in this method of observation and manifest its interest by making use of the results. There is no doubt but that the employment of such aids became more necessary, when, through the foehn phenomena, meteorologists first recognized the importance of ascending and descending currents and noticed that the formation of clouds has as close a relation to the rising currents as has the fine weather to the descending currents. Of the physical changes that are going on around us in the atmosphere, a general theoretical picture could be gained, but the deeper understanding of the phenomena required that the observer, or at least his instruments, should follow the rising and sinking air currents and so furnish more exact conclusions about temperature and humidity. Precisely for the solution of questions relating to the vertical currents, the new methods of scientific aeronautics have rendered important services and have given an insight into the mechanics of the phenomena that could not be gained in any other way. However, all preceding results are only beginnings and here, as in other branches of knowledge, it has proved to be the case that every fresh investigation raises new questions; in this case the relation of these vertical currents to whirls of air, stratification, etc. Earlier investigators had already perceived the importance of aeronautics for meteorological researches. When Charles, the inventor of the hydrogen balloon, made his several ascensions in 1783, he took with him a barometer and a thermometer, as did the American aeronaut [Jeffries] who ascended from London during the same year.* It was not until very lately that Germany took part in this work, or about the year 1880, but then with an instrument markedly superior, namely, Assmann's aspiration-psychrometer, and through the munificence of the German Emperor she was enabled to carry out the work on a large scale. For the second time the representatives of scientific aeronautics now meet on German soil and thereby recognize the importance of our efforts. But much indeed has been done for this new research by M. Teisserenc de Bort at Trappes, near Paris, through the perfection of the *ballon-sonde*, the unmanned balloon carrying self-recording instruments, and by Mr. Rotch, of Blue Hill, through his application of kites. Both methods are so good that by their use a great impetus has been given to meteorological research, whereby it is easily understood that there should be uniform rules for their employment. Looking backward it may be said that the international meetings for the organization of meteorological research, in 1854 at Brussels, in 1873 at Vienna, and in 1879 at Rome, are landmarks in the progress of the science, and that when, in September, 1896, the International Committee for Scientific Aeronautics was appointed, the plan had been so well considered and the technical necessity was so evident that there was entire unanimity in the deliberations and resolutions. The originator of the idea of the unmanned balloon was the late Gaston Tissandier, who enthusiastically explained the scheme to the speaker in 1886, although nearly ten years elapsed before its realization. This work will be fruitful, for wind and clouds have no political boundaries and the sun belongs to us all. Consequently, we are all striving, for various reasons, toward the same goal, and the motto *viribus unitis* will be, as ever, the decisive measure of the result.

Professor Cailletet, of Paris, responded for the foreigners present, and then Prof. Dr. Hergesell, after thanking the preceding speakers, spoke as follows:

As already indicated by Dr. von Bezold, the foundation, on common principles, of an international union for scientific aeronautics was, to a certain degree, long since foreshadowed. Everywhere—in Paris, Strasburg, Munich, St. Petersburg, and Berlin—aeronautical experiments for the scientific exploration of the atmosphere had taken place, and since a general wish was expressed to unite the separate efforts in a common cause, a favorable time to do this seemed to be in the autumn of 1896 at the conference in Paris of the directors of the meteorological institutes. France, the cradle of aeronautics, was the chosen ground, because there, independently of the German and Russian experiments, a most promising method of investigation had been developed that had already produced good results; for the French experimenters, Colonel Charles Renard and Messrs. Hermite and Besançon, all members of our Commission, had simultaneously put into execution the plan of exploring the highest strata of the atmosphere with free balloons carrying only self-recording instruments. Not the least service of our Commission has been to render the method of unmanned balloons comparable with the exact measurements in manned balloons as they are made in Berlin. The first task of the union was not to execute as many simultaneous manned and unmanned ascensions as possible, but rather to establish a foundation for such cooperation by prescribing accurate instruments, built according to identical principles. During our first meeting, in April, 1898, at Strasburg, the difficult problem of obtaining a uniform instrumental equipment was solved in a general way. Since then our manned balloons, here and abroad, carry the aspiration-psychrometer, which Dr. Assmann, in cooperation with the late Captain von Sigsfeld, had devised, and the unmanned balloons are provided with the normal registration apparatus which the indefatigable Teisserenc de Bort has constructed so skilfully. The registration balloon from that time has been the most powerful tool in dynamical meteorology and has furnished astounding data for the cold atmospheric strata up to a height of 20 kilometers, which are confirmed to a height exceeding 10 kilometers by the ascensions of the brave Berlin aeronauts, Berson and Süring, who have ascended so far in these regions. Since November, 1900, on the first Thursday of every month simultaneous ascensions have occurred in Paris, Strasburg, Munich, Berlin, Vienna, St. Petersburg, and Moscow, and on May 5, 1902, the 213th registration balloon of the International Commission was sent up. What a tremendous task, but how important the results! Until very recently it was assumed from Glaisher's observations that at no great height there prevailed, year in and year out, all around the globe, a nearly constant temperature. This view has been proved wholly erroneous. The assumed meteorological inaction at great heights does not exist, for the changes as regards temperature are as great at 10,000 meters as at 4,000. At the former height there are differences of temperature between St. Petersburg and Paris of 3° to 40° centigrade. Further, the observations have proved that the temperature does not steadily decrease upward, but that strata exist which often possess great differences of temperature. This stratification is one of the most important objects of the present investigation. And the future? Systematic meteorological research is at present carried on over only a small portion of the globe. Even in Europe, in the north there is lacking Scandinavia, and in the south Italy and Spain; but the presence of representatives of these countries at our meeting gives the hope of speedy cooperation. A plan for a meteorological cruise of a steamer to fly kites will also be discussed, for the meteorological exploration of the Tropics must be extended, and the participation of England in our endeavors gives us hope that India may be claimed as a region for investigation. *Per aspera ad astra*—that may be setting our goal too high, but, *per aspera ad altas et ignotas regiones*, up to the regions which hide the great secret where the weather comes from—that we certainly should fix as our goal!

The scientific sessions were now begun. At the first meeting of the Committee the following fifteen persons, nominated as members of the Committee, were elected by the Congress: Director Palazzo of the Central Meteorological Office and Major Borgatti from Italy; Director Arcimis of the Meteorological Institute and Major Vivez y Vich from Spain; Secretary Shaw of the London Meteorological Office, the Presidents of the British Meteorological and Aeronautical Societies, and Major Trollope, from Great Britain; General Neureuther, President of the Aeronautical Society of Munich; Inspector Kusnetzof

* See R. De C. Ward, in the Am. Met. Journal, Vol. IX, p. 58.—ED.

of the Russian Meteorological Service; Captain Weber, of Bavaria, Major Klussman and Captain Gross of Berlin, Director von Konkoly and Dr. von Tolnay of the Hungarian Meteorological Office. Among the first questions to be discussed was the landing of manned balloons in foreign countries. After a long debate, the following resolution was adopted: "The Commission expresses the wish that through diplomatic channels negotiations should be undertaken authorizing the necessary scientific apparatus to be carried in its ascensions. When landing in a foreign country, if difficulties arise over the photographic plates they are to be delivered for examination or development to a competent official to be named by the Commission." As regards the question of obtaining means to publish regularly the observations made during the simultaneous ascents, it was resolved that a regular official publication is indispensable.

At the second meeting Dr. Assmann presented a new volume containing the results of the work, for the two years ending last autumn, at the Aeronautical Observatory near Berlin, maintained by the Prussian Meteorological Institute.

General Rykatchef, Director of the Central Physical Observatory at St. Petersburg, spoke on the preliminary results attained with kites, *ballons-sondes*, and manned balloons during the past five years in Russia. Scientific aeronautics in Russia date only from 1899, with the exception of some years of preparatory work. Still there have been a large number of ascensions; 13 of the 60 kite-flights were above 3,000 meters, while the *ballons-sondes* reached 14,200 meters. The inclement climate of Russia occasions many unusual difficulties, for instance, the kite wire on the reel becomes thickly coated with frost, rendering the unwinding difficult, or both wire and kites in the air are so thickly incrusted with frost work (five millimeters or more) that the kites often fall to the ground. Kites were used chiefly at the stations in Pavlosk and St. Petersburg, and thereby special details were obtained in the lower strata of the diurnal and annual influence on the vertical decrease of temperature up to 3,000 meters. It was found that in summer and during the daytime the decrease of temperature with increasing height proceeds more rapidly, and, on the contrary, that in winter and during the night hours there are large inversions of temperature. In anticyclones large inversions occur in the lower strata and a rapid decrease of temperature in the higher strata. Often, in the space of a few minutes there were observed great fluctuations of temperature caused by different currents, and the study of temperature inversions showed that these take place at greater and greater heights as the time of day is later. General Rykatchef exhibited an anemometer, constructed by his assistant, Mr. Kusnetzof, for the registration of wind pressure during kite flights. The instrument has bridled Robinson cups which act like a dynamometer, and record the gusts of wind on a revolving drum. In closing, the speaker announced that the Czar had given a considerable sum of money for the continuation of this investigation of the different strata of the atmosphere in Russia by means of balloons and kites.

M. Teisserenc de Bort, of Paris, presented the results of his observations on the decrease of temperature in the high atmosphere, as obtained from the ascensions of 258 *ballons-sondes*, which had reached or exceed 11,000 meters, the total number of ascensions being 540, all of which were made at night to avoid the effect of insolation. The concordant and remarkable result is that in the layer between 8,000 and 9,000 meters the decrease of temperature becomes slower, ceasing entirely at 11,000 meters, while above that height a warming may set in, with fluctuations of 1° to 3° centigrade, making the temperature here on the average nearly constant. In the summer this isothermal layer appears to lie somewhat higher, or between 13,000 and 14,000 meters. It is lower during the prevalence of a depression, but 4,000 meters higher during a high pressure, so that the zone exceeds the height of the cirrus clouds. The lowest temperatures, occurring in a high pressure, were —67° and —72°, but in March the exceptionally low temperature of —75° centigrade was observed. Whether the absolute minimum of temperature has been reached here requires further proof and as to the cause of this striking phenomenon there are only conjectures. Have we at these great heights aerial conditions working on a grand scale, where the cyclonic whirls of the lower atmosphere do not penetrate and the currents flow uninterruptedly, and must we assume, with Maxwell, that there are stages in molecular movement where gravity and its attendant phenomena no longer act?

Prof. Dr. Assmann said that in a memoir on this subject which he had presented to the Berlin Academy of Sciences he showed that the observations of the Berlin Aeronautical Observatory, although obtained by a somewhat different method, led to the same conclusion as that which had been reached at Trappes. Above 10,000 meters the temperature oscillates and does not appear to decrease, although beyond the variable stratum, at 17,000 meters, and recently as high as 19,500 meters, the temperature was again found to decrease, so that the possibility of an absolute minimum of temperature is by no means excluded. The Berlin observations were executed with specially constructed balloons of Para rubber, which entirely avoided in the daytime the influence of solar radiation on the instrument, which was also inclosed in double polished tubes. During the six high ascensions, of which the observations have been reduced, the results stated by Teisserenc de Bort were confirmed and rises of temperature amounting to 9°, with the decreases of temperature already mentioned at still greater heights, were found. During the high ascension of Berson and Süring on July 31, 1901, the temperature of —40° was read at the identical height where the thermograph of a registration balloon, sent up at the same time, recorded —38.4°. Berson thinks it probable that the increased warmth of the anticyclone ceases between 6,000 and 8,000 meters and at greater heights the air in the anticyclone becomes colder than that in the cyclone.

Professor Palazzo, director of the Central Meteorological Office at Rome, announced that Italy would now participate in the international scientific exploration of the atmosphere. Through the aid of the Minister of Agriculture three stations for kites are proposed; one on Mount Cimone (2,165 meters), another on Etna (2,942 meters), and a third outside of Rome, near the Fort of Monte Mario. The Minister of War has ordered that the ascensions by officers of the balloon corps shall take place on the days of the international ascents. Information was given about the observatory for the study of the physics of the atmosphere, now in construction on Monte Rosa at a height of 4,560 meters, which is expected to be completed next summer. The observer is to be a scientific expert who, in addition to making the usual observations, will undertake scientific researches, remaining all summer at the observatory and going up as often as possible in winter. The observatory will also be open to other scientific men. In connection with this communication there was a discussion concerning the interest of scientific aeronautics in physiological investigations which will form an important part of the work of the high-work observatory mentioned. Professor Zuntz, who had passed eight days on Monte Rosa, stated that notwithstanding the much diminished quantity of oxygen in the air there is a great increase in the amount of oxygen used by the human organism, an effect that had not been observed when the atmospheric pressure was artificially reduced at low levels, and the cause of which is of vital interest to the aeronaut. Dr. von Schrötter, of Vienna, pointed out that the study of the chemical intensity of the light in the spectrum at great heights was one of the tasks for a high-level observatory which interested also the aeronaut. The photographic plate furnishes

the best means for the study of chemical climate, but a distinction must be made between upper and lower light, the latter being reflected from the clouds and probably acting chemically in a different way from the first, permitting, however, conclusions to be drawn as to the absorbing power of cloud strata. It appeared from the remarks made on this communication, that already in Berlin and Munich researches are in progress with photographic plates to record the action of the ultra-violet rays.

Prof. Dr. Assmann, Director of the Aeronautical Observatory of the Prussian Meteorological Institute, described his registration balloon of caoutchouc or Para rubber, which was one of the novelties of the meeting: The ordinary *ballon-sonde*, made of silk or paper and open at the bottom, has the great disadvantage that, when it approaches equilibrium in the upper strata of the atmosphere, its velocity of ascent decreases and the effect of insolation on the thermograph becomes greater, without it being possible to determine afterwards the place where the solar disturbance began during the ascent or where it disappeared during the descent; in fact, it is only in certain cases that we can distinguish between the insolation influence and the curious thermal anomalies that have been described by Teisserenc de Bort and Hergesell. The use of a closed balloon made of elastic material has this advantage, that in proportion as the inclosed gas expands, the ascensional force is increased so that the balloon rises faster with augmenting height until it bursts and then falls to the ground with diminishing velocity, because checked by a parachute. The time of equilibrium is therefore reduced to an instant, and although the higher the altitude the more intense is the solar radiation and its effect on the thermograph, yet the speed of ascent and descent is also increased and, consequently, the ventilation, which counteracts the radiation, is likewise stronger. The least possible weight of balloon envelope and of registering apparatus is required, for the lighter the whole apparatus, the less gas is needed, and the smaller the quantity of gas the more it can expand before the envelope bursts at a proportionally greater height. The meteorograph of Dr. Assmann has no clock movement, the time being unimportant; but a disk is turned by the metallic thermometer while the barometer draws a pen horizontally across the disk, and so the spiral curve indicates heights and corresponding temperatures. The apparatus exhibited weighed but 380 grams, and with the protecting basket, 500 grams. Since ink would freeze at great elevations the trace is made by a pen containing a solution of saltpeter, which writes on the disc coated with lampblack, treated with a solution of "tonsol." The chemical reaction gives a red trace that can not be obliterated by handling nor by immersion in water. The time required for an ascent to 15,000 meters is about one hour and for the descent two hours, so that the balloons do not travel very far and are usually recovered within three days. The diameter of the envelope at the start is 1 or 2 meters only, and it does not require to be completely filled with hydrogen to exert the necessary initial lift of 2 or 3 kilograms. A balloon with a diameter of 1 meter, when expanded to 2 meters has its volume increased eight times and consequently should rise until the atmospheric pressure is one-eighth, or to a height of about 15,000 meters. A balloon formed by dipping a mold into a solution of Para rubber, was expanded to sixty-four times its original volume before it burst, which indicated that it would have risen to about 38,000 meters.

Dr. Valentin, of Vienna, spoke on the sluggishness of thermographs in registration balloons, which he had investigated by exposing the Richard thermographs alternately to the action of cold and warm currents of varying velocity and comparing the time necessary to acquire the temperatures shown by sensitive mercurial thermometers. Prof. Dr. Hergesell believed that it was better to employ the most sensitive and accurate thermometers rather than to try to determine the corrections for sluggishness. He exhibited such an instrument, as did Teisserenc de Bort. The French instrument has the Bourdon tube insulated by a block of hard rubber, which prevents the injurious conduction of heat. Comparisons between an instrument insulated in this way and one not insulated gave differences which increased with the height of the balloon and at 12,000 to 14,000 meters reached 6°, an amount that justified the insulation. Prof. Dr. Hergesell spoke on the same subject in connection with a model of his new barothermograph for *ballons-sondes*. A metal strip is sensitive to changes of temperature in proportion as its weight is less and its surface is greater, consequently in his thermograph a very thin German silver tube is inclosed in a larger tube. To transmit the changes in length of the inner tube to the recording pen nickel-steel is employed, because this alloy has a very small coefficient of expansion. He has compared this apparatus with a thermograph of Teisserenc de Bort, carried by the same paper balloon and ventilated in the same way, and has found that during the ascent the first always gave lower values than the last, that is to say, it was more sensitive, and only at the maximum height, where the apparatus remained for some time at the same level, did the records approach each other. This apparatus seems also applicable at central stations where very sensitive thermometers are employed to record brief changes of temperature. It was recommended that comparative tests of the instruments of Assmann, Hergesell, and Teisserenc de Bort should be made when attached to the same balloon and that comparative readings of the two last instruments should be executed at night, to avoid errors due to insolation, at the stations of Berlin, Strasburg, and Paris. In connection with this subject, Captain von Parseval mentioned a thermometer with which his late colleague, Captain von Sigsfeld, had experimented, that was based on an entirely different principle, namely, the alteration in the specific weight of air with change of temperature. Major Vivez y Vich exhibited a "statoscope," invented by Captain Royas, designed to show the aeronaut whether his balloon was rising or falling, and Mr. Patrick Alexander, of Bath, England, described an apparatus to control the motor of a flying machine from the earth by using Hertzian waves.

At the third meeting the subject of kites and kite stations was opened with a paper by the writer on the exploration of the atmosphere over the ocean. The use of the kite on land is limited to favorable circumstances, since the wind must have a velocity of at least 5 or 6 meters per second to raise the kites and can not exceed a certain maximum strength without endangering the wire by an excessive pull. At sea, however, the motion of a steamer at a velocity of 10 or 12 knots, will almost always produce a suitable kite wind, if it does not already exist. In order to demonstrate this, in August, 1901, the writer crossed the North Atlantic on a steamer and found five out of eight days suitable for flying kites. Only on one day was the relative wind too light and on two days too strong, but the wind would always have been favorable had it been possible to alter the course of the vessel. These successful results led the writer to propose a meteorological kite expedition to the trade wind and equatorial regions of the Atlantic Ocean, where almost nothing is known of the upper currents. To defray part of the expense application has been made to the Carnegie Institution for a grant of $10,000, but it was considered that the recommendation of the present Congress might aid in securing favorable action. Applause showed the approval of the meeting, which was voiced by Drs. von Bezold and Hergesell. The former, especially, pointed out the importance and the pressing need of meteorological observations over the ocean, where, in consequence of other

methods of warming and cooling the air, very different conditions must exist than prevail over the land, and our ignorance of them is no longer to be tolerated. Professor Köppen, of Hamburg, expressed himself in a similar manner and made the interesting announcement that according to the programme of the Scandinavian Hydrographic Congress to explore the Baltic and North seas in the interest of the fisheries, four cruises a year were proposed on which meteorologists would be given an opportunity to study the atmosphere above these seas. Therefore the Deutsche Seewarte will cooperate and the speaker expected to fly kites on the first voyage of the present summer. Professor Wagner, of the University of Göttingen, said that the Göttingen Society of Sciences had, at the request of the Aeronautical Committee, furnished the geophysical expedition which was sent to Samoa about a year ago under the leadership of Dr. Tetens with kites and instruments in order to obtain meteorological observations above that island and on the return voyage over the Pacific Ocean. Dr. Hergesell mentioned that on the Lake of Constance meteorological kite flights were to be undertaken, Count von Zeppelin furnishing the vessel and the meteorological service of Alsace-Lorraine the apparatus. General Rykatchef promised on the part of the Russian Government that similar observations would be executed over the northern portion of the Baltic as well as over the Black Sea. On motion of Dr. Hergesell the plan of Mr. Rotch for a meteorological kite-expedition in the South Atlantic was fully approved, and the hope was expressed that with the aid of government funds the project might be realized in the near future. Mr. Berson remarked that it was of the greatest importance that the British as well as the Dutch governments should encourage meteorological observations in the monsoon region, and Major Trollope, speaking for Great Britain, said that he would endeavor to have this done. Professor Köppen mentioned his work with kites at Hamburg and presented a publication in the Archiv der Deutschen Seewarte describing it. He also stated that through Scandinavian and French cooperation, effected by M. Teisserenc de Bort, kite flights would be made at Viborg, in Jutland, during the next year, simultaneously with those at Hamburg and Berlin, so that interesting sections of the barometric depressions traversing north Germany would probably be obtained. Dr. Hergesell, for lack of time withdrew his paper on mountain kite stations, and only mentioned that kite flights had been made from the Grosse Belchen (1,423 meters) in the Vosges Mountains. These numerous communications show the wide extension of meteorological kite flying in Europe over land and sea.

M. Teisserenc de Bort showed a diagram of the results obtained from continuous soundings of the atmosphere, or those made as frequently as possible at his observatory at Trappes during thirty-six days in January and February, 1901, when kites and registration balloons (*ballons-sondes*) were sent almost daily into the higher atmosphere to an extreme height of 12,000 meters. The plotted results throw doubt on the assumption that the barometric depressions bring higher temperatures and the barometric maxima lower temperatures and give an interesting demonstration of the diversity and complexity of the atmospheric phenomena of which it is the aim of international aeronautics to ascertain the laws. The speaker urged the necessity of these frequent soundings, and Dr. Hergesell replied that, although this ideal exploration of the atmosphere was not so easily attained, still the simultaneous ascensions might serve a similar purpose.

The fourth meeting was principally occupied with the subject of high ascents. Professor Cailletet, of Paris, showed his apparatus for breathing oxygen at great altitudes. The chief disadvantage of the methods hitherto employed in ballooning consists in the fact that the gas is carried in a compressed state, whereby, since at each breath several liters of gas are used, strong and heavy receptacles are required. If, on the contrary, liquified oxygen is taken, which has almost the same density as water, proportionately small vessels are needed, and these can be given any convenient form. M. Cailletet employs the ordinary pear-shaped glass flask, having double walls separated by an air space and silvered externally, in order that the liquid oxygen in it shall be protected from the conduction of external heat and from solar radiation, and thereby kept in a liquid condition. By working a rubber bulb the liquid gas is driven through a narrow tube, connected with the interior of the flask, into a system of tubes having a larger amount of surface. Here it evaporates and in a gaseous state passes through flexible tubes into a caoutchouc reservoir that hangs from the ring of the balloon and is protected by a net against bursting. Thence the gas, after it has been mixed with atmospheric air, passes to the breathing mask. The mask is fastened by elastic bands in front of the face, so that the aeronaut is always forced to breathe oxygenized air. At the lower part of this mask there is an outlet tube for the expired gases, which is ingeniously arranged so that during inspiration the lower end is automatically closed, and, in order that the expired vapor may not be frozen after condensation and so stop up the tube, its lower end is placed under the clothing.

In the discussion Dr. von Schrötter reminded his hearers that it was Paul Bert who had first called attention to the fact that the want of oxygen was the cause of the pathological symptoms which man showed in rarified air. In regard to the opinion held by some Alpinists as to the inefficiency of oxygen, Professor Zuntz remarked that the exhaustion of the heart, which was not counteracted by breathing oxygen, gives rise to the same symptoms as does the lack of oxygen.

Dr. Süring spoke on the ascension which he had made with Mr. Berson on July 31, 1901, to the height of 10,800 meters, the greatest height yet reached by man. He insisted upon the importance of such high ascents to control the observations otherwise obtained and to make those that require direct vision. Especially are the strata from 5,000 to 10,000 meters not yet adequately explored, and for weather changes they are of great importance, as is indicated by the scarcity of clouds near 4,000 meters and above 6,000 meters. However, the greatest caution is necessary in these dangerous high ascensions, and all precautions should be carefully followed. The speaker explained the causes of sickness in the upper air, based on his own experience. Dr. von Schrötter also spoke on the physiology of high ascents. His experiments to a height of 7,500 meters in a balloon, and under a pressure of 230 millimeters of mercury in a pneumatic cabinet, confirmed the classic ones of Paul Bert as regards breathing oxygen, but there is still another kind of sickness at great heights, consisting in the formation of larger nitrogenous globules in the blood than can be taken care of in a normal way when the atmospheric pressure is diminished, and the pressure of these globules disturbs the nervous centers and occasions symptoms of paralysis. Great rarifaction of the air, when of short duration, has no marked influence on the number of red corpuscles. From a physiological standpoint there is still much to be investigated, notably as to endurance of cold, dampness, and light at high altitudes. Dr. von Schrötter exhibited a breathing mask of his own, which was to be tried the same day, together with the mask of M. Cailletet, during a balloon ascension.

After Dr. Süring's paper, a telegram was sent to James Glaisher in London from the scientific aeronauts of Europe, America, and Asia, in congress assembled, expressing their admiration and remembrance of this distinguished Nestor of meteorologists.* After the day's programme had been completed, Count von Zeppelin called the attention of aeronauts to

* Mr. Glaisher was born in Scotland in 1809.—ED.

a means of showing the existence of vertical currents of air by observing birds of prey hovering over mountains, for where a bird soars there must be a rising current, and hence ascents of *ballons-sondes* in such localities might prove of interest. Lieutenant von Lucanus, in the name of the German Ornithological Society, asked aeronauts to observe the various heights at which birds are found. It is now supposed that the height above the ground at which birds fly does not generally exceed 400 meters, and only occasionally reaches 2,000 meters, the zone usually remaining below the lower clouds. Still, much uncertainty prevails concerning the tracks of birds, and especially the heights of flights, and information is greatly desired.

The fifth session was mostly devoted to a discussion of observations of atmospheric electricity and terrestrial magnetism in balloons. Dr. Hergesell explained that electrical measurements are of such vital interest that the academies of Berlin, Munich, Göttingen, Leipzig, and Vienna were to have been represented at this meeting by Professors von Bezold, Ebert, Wagner, Wiener, and Exner. The latter, who is the Nestor of this branch of physics, was prevented from attending, but Professor Elster, of Wolfenbüttel, was present among the experts. Professor Ebert, of Munich, said that constituents containing electrical charges had been found recently in the air through their physical properties. These carriers of electricity are called "ions," or, more correctly, "electrons." At the earth's surface their presence may be shown by the dissipation apparatus of Elster and Geitel, and the smallest quantity of electricity may be recorded by means of an electrometer. The speaker had adapted this apparatus for use in balloons, and by employing an aspirator a fixed quantity of air could be drawn over the dissipating body and absolute measurements made of the amount of free electricity contained in a cubic meter of air. It is of importance in geophysics to know how the capacity of the air for positive and negative electrons varies with altitude and therefore the speaker had made such determinations, finding near the earth many more positive than negative electrons, but whether this is a result of the negatively charged earth is uncertain. In the high strata the inequality tends to disappear, but considerations that throw doubt on the balloon observations relate partly to the electrical discharges produced by the ultra-violet light rays and partly to the indeterminate moment of aspiration in a rising or falling balloon. Professor Ebert considered the cooperation of aeronauts valuable, and cited as a result of the investigation in the Alps that in the foehn wind an excess of positive electrons is found and this disturbance of the electrical equilibrium perhaps may cause the foehn sickness. Professor Elster described two experiments that proved the existence of the electrons, one being the radiation of Becquerel rays after two hours from an insolated and stretched copper wire charged with 2,000 volts. It was agreed by both experts that the cleaner and clearer the air the more electrons it contains. Dr. Caspari, of Berlin, said he had ascertained, during a physiological excursion in the high mountains, that it was not so much the absolute number of ions as the preponderance of those of the same sign which had a physiological influence.

Dr. von Bezold mentioned an investigation of the relation between the foehn and richness in electrons that was undertaken, at his suggestion, by Professor Czermak, of Innsbruck, which showed that the air brought down by the foehn from above carries a greater quantity of ions into the lower air, and so, very probably, there is a similarity between sickness caused by altitude and the well known effect of the foehn on living organisms. In conclusion, Professor Ebert said that the quantity of electrons in the atmosphere seems to have no effect on bodies, but only the violent changes of equilibrium so acted, and therefore an interesting field in the measurement of the dissipation effect was opened for research in balloons. In response to a request from the Academy of Science, the committee resolved to undertake measurements of atmospheric electricity in the international balloon ascents. Professor Palazzo exhibited, for use in balloons, a modification of Exner's electrometer, that gave a continuous photographic record. Dr. von Bezold thought it very desirable that the observations in balloons should include measurements of dissipation as well as changes of potential at different heights. Dr. Linke, of Potsdam, reported the results of his electrical measurements in balloons up to a height of nearly 6,000 meters. Five of the ascents were to determine the fall of potential and six were to study the electrons. In brief, his conclusions were that there is an increase of positive electrons with height in every weather condition, but a relation of the good or bad conductivity of the air to its greater or less transparency. The vertical movement of the balloon introduces errors in the electrometer readings that can hardly be avoided and the speaker cautioned his hearers against intrusting the difficult measurements of dissipation to inexperienced observers. Professor Ebert then described an apparatus for determining in a balloon the horizontal magnetic intensity, which is an improvement of the Heydweiler instrument and permits changes of intensity to be measured without knowing either the astronomical or magnetic meridan. This has not only a high scientific importance but may be of practical importance as affording a method of determining the position of a balloon when within the clouds, or over the sea, or at night. Dr. Marcuse, of Berlin, exhibited a simple instrument that was recommended for general use, by which the aeronaut may ascertain his position from the altitude of either the sun or moon or two fixed stars.

Dr. Kassner, of the Prussian Meteorological Institute, suggested the application of kites and kite-balloons to a series of problems as follows:

Physics.—The measurement of the velocity of sound in the free air is important, in meteorology, for example, for the theory of thunder. It requires a knowledge of the density of the atmosphere and this must be calculated from the pressure, temperature, and humidity. Formerly these elements were determined at the ends of a base line, which ends were usually on mountain summits. The intervening air stratum can now be accurately investigated and, consequently, the measurement of the velocity of sound will be more accurate.

Geodesy and astronomy.—A knowledge of the conditions prevailing in the stratum of air traversed by the ray of light is needed for the computation of atmospheric refraction, and this can easily be obtained by a kite or a captive balloon.

Meteorology.—For studying the action of "hail shooting" registering instruments can be sent up on kites or on captive balloons to determine whether the aerial whirls produced by the hail-cannon really extend up to the clouds, a question that is still awaiting solution.

This completed the programme of papers, but Director Archenhold, of the Treptow Observatory at Berlin, called attention to the probable production, by the volcanic eruptions in the West Indies, of the same phenomenon of luminous dust-clouds in the highest air strata that were seen for years after the great outbreak of Krakatoa in 1883. If the development proceeds as it did then, we should have first brilliant and long-continued twilight phenomena, while the lower strata are filled with dust, and sometime afterwards the luminous clouds at a height of 80 kilometers. Since it is probable that aeronauts may first discover this phenomenon during high night ascents the speaker requested that it should be watched for and this was promised.

Before closing the Congress the resolutions proposed, after undergoing certain modifications, were adopted by the Committee in executive session, the Congress itself being only a con-

sulting and advisory body. Besides the resolutions mentioned already it was determined that the international ascents of balloons and kites during the next year should take place, as has been the case this year, on the first Thursday of every month and that at least one of the *ballons-sondes* liberated at any station should be sent up one hour before sunrise in order that its records may not be affected by solar radiation, and also that the balloon may be seen when it falls to earth in the early morning. The Richard thermograph, with Teisserenc de Bort's insulating device, should be used and the Hergesell instrument having a tube of German silver, instead of the Bourdon tube, filled with alcohol, was also recommended on account of its sensitiveness and durability. Ascensions at other hours and with different apparatus are discretionary. The president, Prof. Dr. Hergesell, in summing up the results of the Congress, which he regarded as eminently satisfactory, laid special importance on the meteorological kite flights that were proposed over seas, lakes, and mountains, and hoped that the British Government, by similar work in India, would help in the investigation of the great Asiatic monsoon region. A grant of money was requested from the German Government to enable the Prussian Meteorological Institute to cooperate with the writer in his proposed investigation of the atmosphere over the Atlantic Ocean. It was announced that in order to facilitate international researches in scientific aeronautics, the formation of an organization, sustained by the various European nations, would be attempted. The Congress was then closed with the usual votes of thanks.

ON THE CALIFORNIA CHARTS OF RAINFALL.

By ALEXANDER G. MCADIE, Professor and Section Director, United States Weather Bureau, dated August 20, 1902.

Referring to the symposium on "Rainfall and charts of rainfall," in the MONTHLY WEATHER REVIEW for April, 1902, I respectfully refer to the map published in the Annual Summary for 1900, of the California Section of the Climate and Crop Service, where it will be noted that in charting rainfall due allowance has been made for the topography of the State. The intimation by Mr. Henry Gannett, on page 224, that in preparing our rainfall maps we only consider the rain gage measurements, is hardly fair to the California service, for the reason that the isohyets in this State have, during the past three or four years, been drawn with special reference to the orography. We do not show the area of the precipitation over the Sierra Nevada to be the same as that measured at Fresno, Stockton, or Owens Lake. Mr. Gannett must have been unaware of the methods followed at this office in charting rainfall, and I will be glad to have his attention called to this matter, as I am sure that he will appreciate our method. A relief map of the State is always placed underneath the tissue paper chart of the State on which the rainfall data are assembled.

On page 225 Mr. F. H. Newell is likewise in error in his statement that the rainfall maps of the Weather Bureau, "while undoubtedly good for the more thickly settled parts of the United States are very misleading for the western two-fifths of the country because the great mountain ranges are ignored." On page 226 Mr. Newell suggests that some one familiar with the topography should sketch the rainfall map. It is believed that this is not nearly so good as the method which we have followed for years.

After carefully reading the symposium published in the MONTHLY WEATHER REVIEW on "Rainfall and charts of rainfall," I fail to see wherein the chart of precipitation published by the California Section can be improved under the present limitations of our knowledge. It would be unwise to make use of an indefinite factor based upon the element of forestation. Mr. Gannett's contention[1] that certain timber belts upon the Sierra Nevada might be utilized in drawing the isohyets fails to find support in the views of Professor Goodale, Professor Sargent, Professor Merriam, Professor Fernow, and our forester, Mr. Pinchot. To introduce such a factor would certainly make the map of rainfall in California, in the words of Dr. Hann, "a subjective work of the imagination." As an illustration of the uncertainties attending forest growth and its relation to rainfall I would call attention to a redwood grove on the windward side of Mount Tamalpais. The rainfall from May until October is nil, but below the crest of the mountain dense fog prevails in great blankets. The crowns of the redwood trees, averaging possibly 200 feet from the ground, are bathed in moisture for from five to eight hours nearly every day during the summer months. The character of the forest here is, therefore, largely determined by temperature, humidity, and shelter from high winds rather than rainfall.

With reference to Mr. Newell's contention that our rainfall records are not kept with that degree of accuracy which we profess (see page 226), I would say that in California we have many earnest rainfall observers who for long years have maintained records which I believe will compare favorably with any set of instrumental records maintained by any institution in the world. Our records show cases where observers have carefully measured the dimensions of their collectors and receivers, and finding a difference in the third or fourth decimal place from the figures given by our Instrument Division have reported the same to this office.

Again on page 225 Mr. Newell contends that our rainfall maps are misleading in that few, if any stations, can be used in accurately measuring the amount of water flowing from mountain streams. Possibly the methods employed in measuring the total volume of discharge of these streams for a year are at fault.

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The hydrographer assumes that mountains necessarily cause a rainfall divide. In a State like California with mountain systems running at various angles to the prevailing air movement, and where wind circulations are frequently reversed with seasonal changes, the determination of average rainfall is a difficult problem. The greatest rainfall may or may not occur beyond the crest of a given range. Should it occur on the side of the divide farthest from the origin of the rain bearing winds any argument based upon elevation and the run-off in a given watershed would be untenable.

I have in recent conversation with Mr. Newell called his attention to the care with which the isohyets have been drawn in California, and I now understand that his criticism did not apply to California. We are indeed only too thankful to have our work criticized if the criticism shall lead to improvement.

In place of the suggestion of Messrs. Gannett and Newell that our rainfall charts be modified so as to "obtain the relations between the flow of streams, the altitude, the vegetation, and the rainfall" (see page 206), would it not be better to begin a systematic study of the forces at work in the formation of the raindrop? Then, possibly, we shall be able to discuss intelligently the true values to be allowed for the influence of forests, mountains, timber belts, etc. From the office of the Weather Bureau at San Francisco one can see day after day vast quantities of condensed water vapor passing inland, undergoing many changes and yet without resulting precipitation. Even if this fog and vapor could be measured it would be improper to allow for it in drawing the rain chart, and yet it plays an important part in modifying climate.

In conclusion, I repeat that the isohyets in California have been drawn with care, and as much allowance made for topography as the present state of our knowledge permits. Every effort will be made to maintain rainfall data of a high degree of accuracy. The criticism of our maps was made without a

[1] Page 206 Monthly Weather Review for April, 1902.